NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

CONFIDENTIAL BULLETIN

INVESTIGATION OF A LOW-DRAG GUN PORT IN THE NACA TWO-DIMENSIONAL LOW-TURBULENCE TUNNEL

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SUMMARY

Tests were made in the NACA two-dimensional low-turbulence tunnel of three gun ports with a height of approximately 4 percent of the chord faired into an NACA 66,2-213 low-drag-airfoil section by bulging the section at the gun port. Gun ports faired in this manner had practically no effect on the maximum lift and the critical compressibility speed of the section and showed only small increase in the drag in the range of lift coefficients for high-speed and cruising-flight conditions.

INTRODUCTION

Previous tests conducted in the NACA two-dimensional low-turbulence tunnel indicated that gun ports cut directly in the leading edge of the wing caused increases in the drag large enough to appreciably affect the performance of the airplane when the height of the opening exceeded 13 percent of the maximum thickness of a 16-percent-thick section. It may sometimes be desirable to have an opening in the leading edge as high as 5 inches in order to permit some movement of the muzzle of the gun. For a wing of 125-inch chord and 13-percent maximum thickness, the height of this opening would be 30 percent of the maximum thickness.

The purpose of this investigation is to fair a gun port of this size (approx. 4 percent of the chord) into a 13-percent-thick low-drag-airfoil section without changing appreciably the aerodynamic characteristics of the original section. In some cases structural limitations may make it impossible to avoid the protrusion of gun barrels from the leading edge of the wing. A detailed investigation is planned to find methods of reducing the adverse effects of such an installation.

APPARATUS

The gun ports were faired into an NACA 66,2-213 airfoil section. The model had a chord and a span of 3 feet. Consideration of the data given in reference 1 indicated that placing an opening of 30 percent of the maximum thickness in the leading edge of a 13-percent-thick section would result in a serious increase in the drag.

In order to reduce the ratio of the size of the opening to the maximum thickness, the wing was bulged to a thickness of 16 percent at the section through the center of the gun port. The bulged portion of the wing had a span of 6 inches. Figure 1 shows a front view of the gun-port model. Thickness ordinates for the section through the center of the opening are given in table I.

In order to obtain a properly faired-out leading-edge shape at the spanwise ends of the gun port, the leading edge was built out as shown in figure 2.

SYMBOLS

V free-stream velocity

V_n velocity of air in entrance of opening

q free-stream dynamic pressure $\left(\frac{1}{2}\rho V^2\right)$

p local static pressure

H free-stream total pressure

S pressure coefficient $\left(\frac{H - p}{q}\right)$

H_t total pressure at exit

ΔH loss of total pressure through duct $(H - H_t)$

c_{d_o} section profile-drag coefficient $\left(\frac{d_o}{qc}\right)$

c_l section lift coefficient $\left(\frac{l}{qc}\right)$

α angle of attack, degrees

A_t area of trailing-edge exit

A_n area of leading-edge entrance

x distance along chord from leading edge of airfoil

c chord

ρ mass density

d_o section drag

l section lift

R Reynolds number

TEST METHODS

The tests were conducted in the NACA two-dimensional low-turbulence tunnel at a Reynolds number of approximately 3.77 million. The model was tested with the three widths of gun ports shown in figure 3. The exit (fig. 4) was changed with each gun port to maintain a flow rate V_n/V of approximately 0.46 in the low-drag range of lift coefficients. Consideration of the data of reference 1 indicated that this flow rate should give a satisfactory range of lift coefficients for low drag. Flow measurements were made by measuring static pressure and total pressure at the center of the exit.

The drag was measured by the wake-survey method at a number of spanwise positions. All drag in excess of the plain-wing drag was attributed to the 6 inches of span over which the bulge for the gun port occurred. The plain-wing drag was determined by moving the rake spanwise until it was outside the region affected by the gun port. Each gun port was tested through a range of angles of attack to determine its range of lift coefficient for low drag.

The lift was determined from changes in pressures along the floor and the roof of the tunnel due to the presence of the model. Values obtained in this manner are in good agreement with those obtained by pressure—distribution measurements. A lift curve from zero through maximum lift was obtained for the model with gun port 1.

Pressure distributions were made with small static-pressure tubes of 0.040-inch outside diameter, mounted 1/8 inch from the surface at a number of positions along the chord.

RESULTS AND DISCUSSION

The results of the tests corrected for tunnel-wall effects are given in coefficient form in figures 5 to 11. For comparison, in figure 5 is given the drag in coefficient form for each of the three gun ports together with that for the NACA 66,2-213. The drag increment, due to the presence of the gun port, is relatively small except at high lift coefficients. A part of this increase is contributed by the increasing loss of total pressure in the duct. (See fig. 6.) Because of the low values of the dynamic pressure inside the duct obtained by the low entrance velocity (fig. 6) and the internal expansion of the duct, the increase in drag due to the presence of a gun should be small.

As shown in the lift curves (fig. 7), the presence of this type of gun port in the NACA 66,2-213 airfoil section has little, if any, effect on the maximum lift of the section.

A comparison of the pressure distribution for the NACA 66,2-213 airfoil section, taken 9 inches to the right of the center line of the opening (fig. 8) with the pressure distribution at a number of locations over the bulged section (figs. 9, 10, and 11), shows that the maximum value of S over the bulged section is no greater than that for the original section. The critical compressibility speed of the bulged section should, therefore, be no lower than that for the original section. The pressure distribution taken $1\frac{1}{2}$ inches to the right of the center line of the opening (fig. 10) extends over the built-out portion of the leading edge (fig. 2) and shows that this manner of fairing the leading edge produces a satisfactory pressure distribution.

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REFERENCE

1. von Doenhoff, Albert E., and Horton, Elmer A.: Preliminary Investigation in the NACA Low-Turbulence Tunnel of Low-Drag Airfoil Sections Suitable for Admitting Air at the Leading Edge. NACA A.C.R., July 1942.

TABLE I

THICKNESS ORDINATES, SECTION THROUGH

CENTER OF GUN PORT

x (percent c)	y (percent c)
0	2.145
.5	2.550
.75	2.683
1.25	2.910
2.5	3.355
5.0	4.068
7.5	4.673
10	5.190
15	6.016
20	6.642
25	7.121
30	7.486
35	7.754
40	7.925
45	7.997
50	7.957
55	7.780
60	7.425
65	6.832
70	6.014
75	5.046
80	3.999
85	2.953
90	1.987
95	1.207
100	.770
Leading-edge radius: 0.161 percent c	
Location of leading-edge radius center:	
0.161	2.145
Location of fairing point in opening:	
0.261	1.967

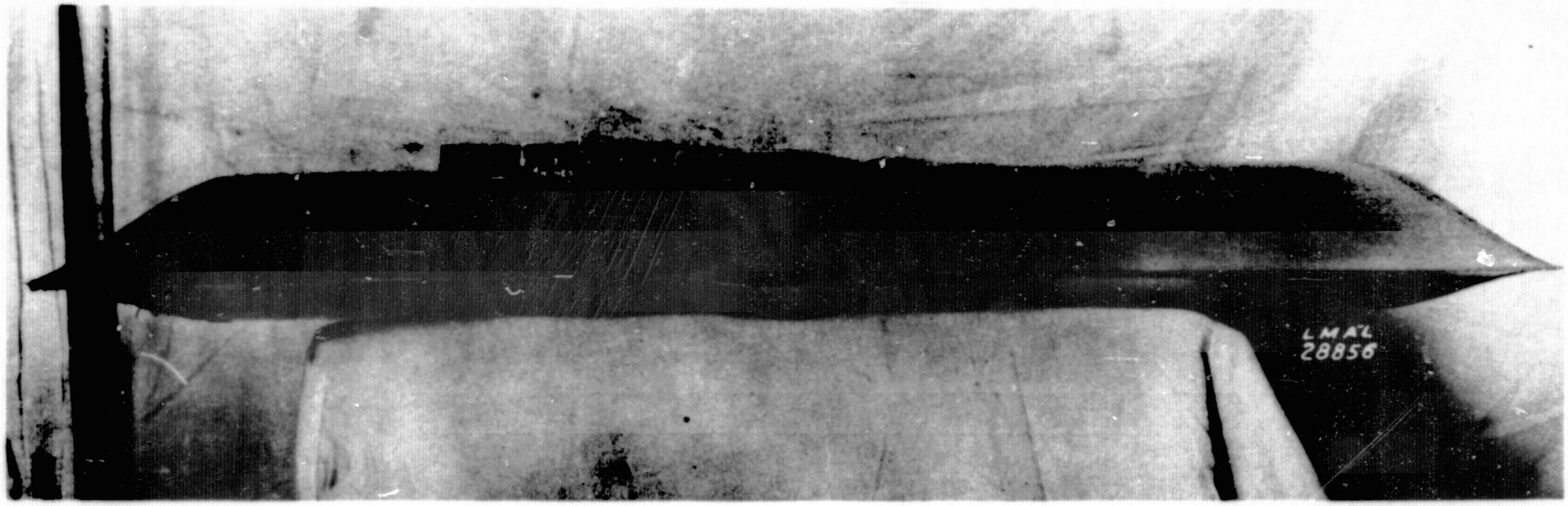

Figure 4.- View of the gun-port model showing typical exhaust used for gun ports.

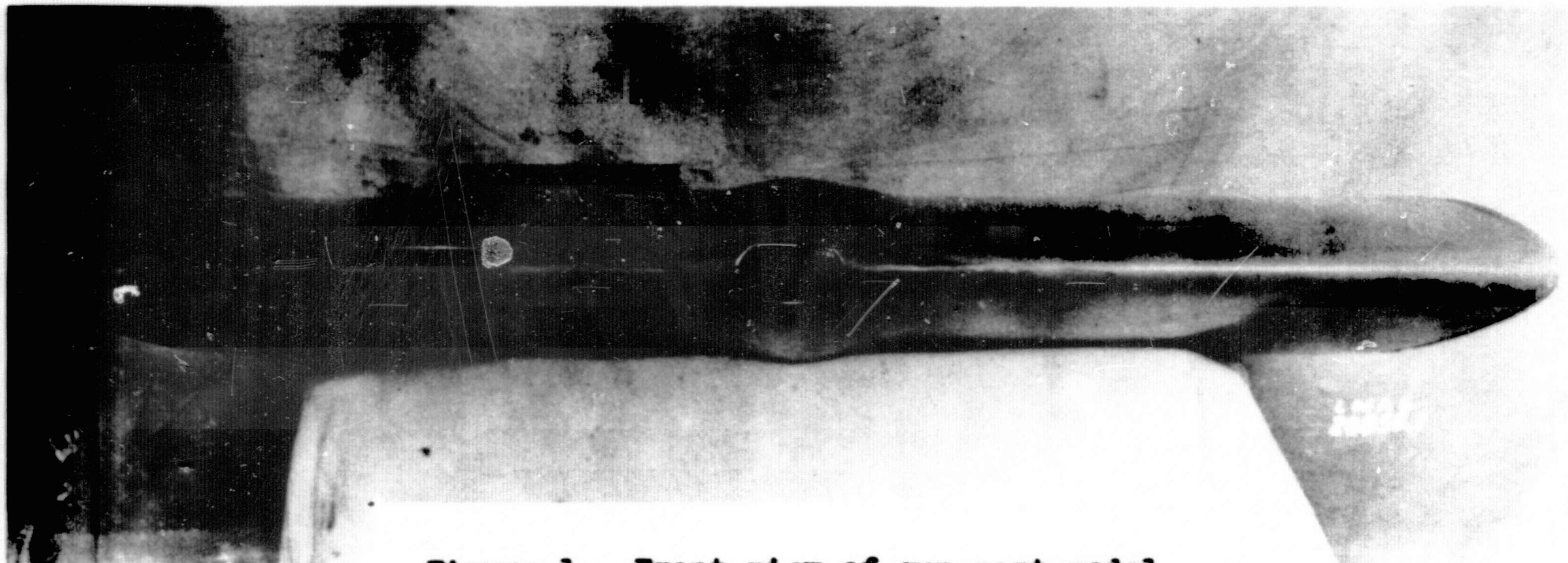

Figure 1.- Front view of gun-port model.

Figure 2.- View showing method of obtaining rounded leading-edge shape as gun port was reduced in width.

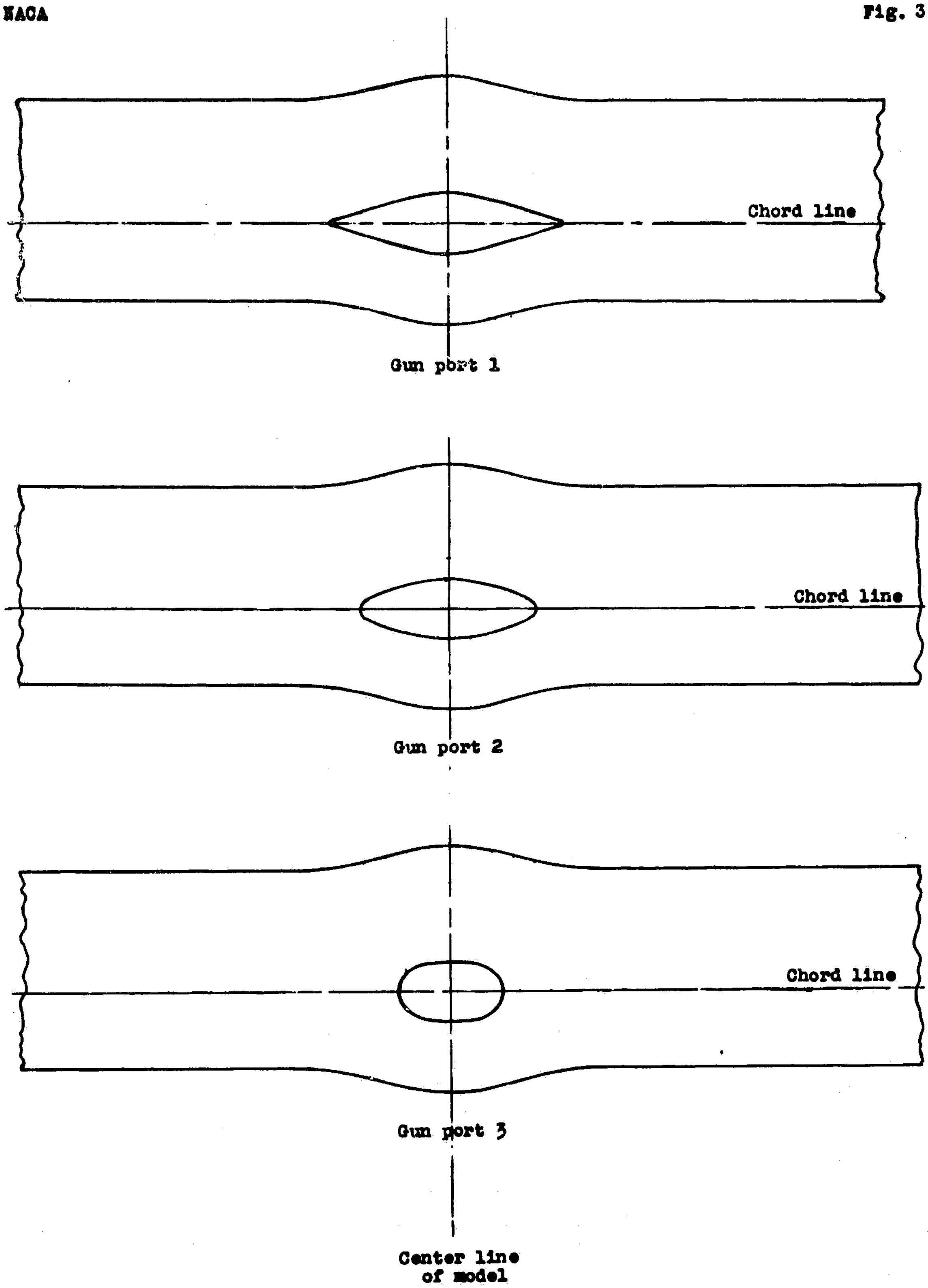

Figure 3.- Sketches showing the relative size and shape of three gun ports tested.

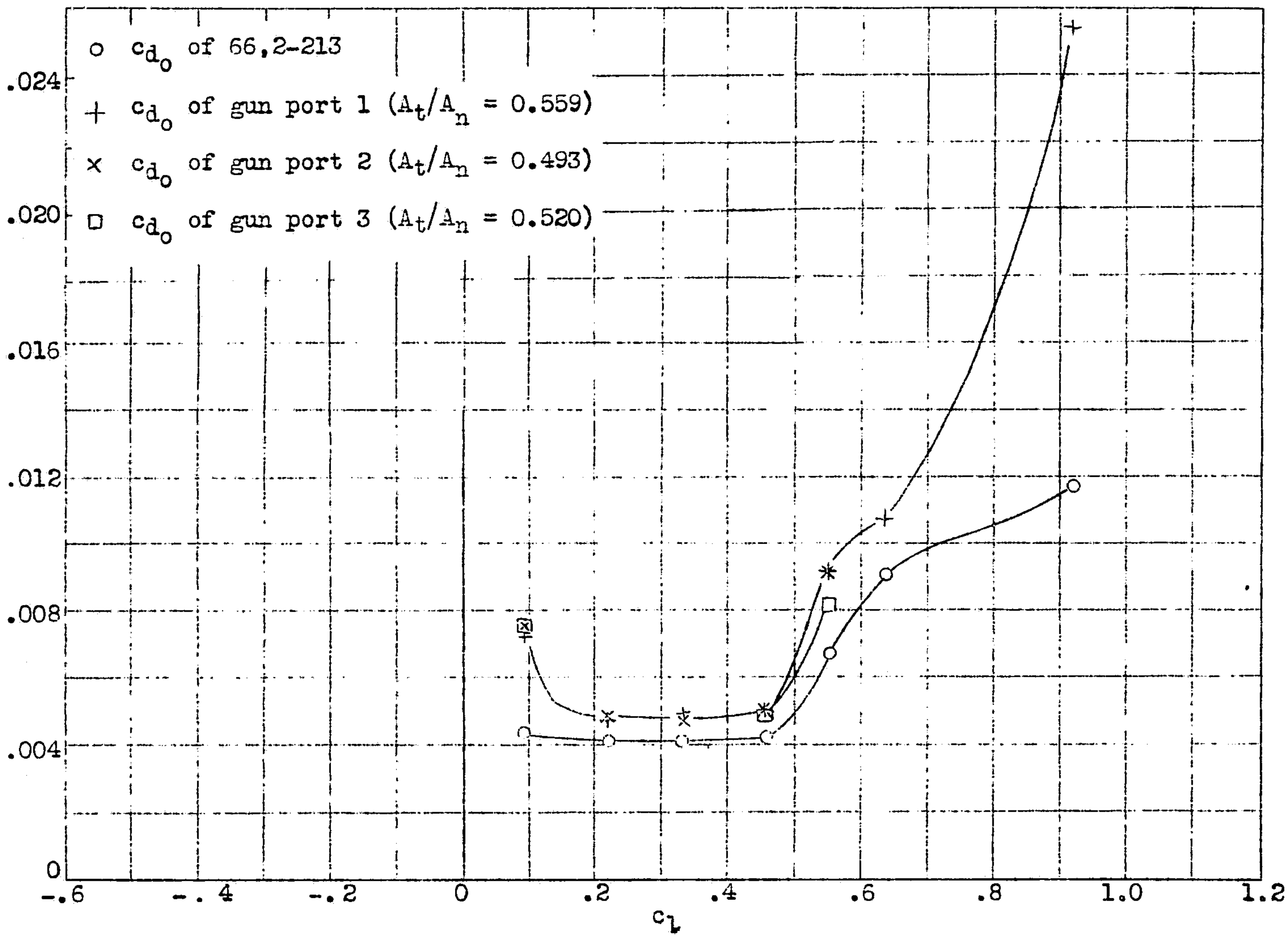

Figure 5.- Comparison of section drag coefficients for NACA 66,2-213 airfoil section and the model with gun port. R, 3.77 x 10^6.

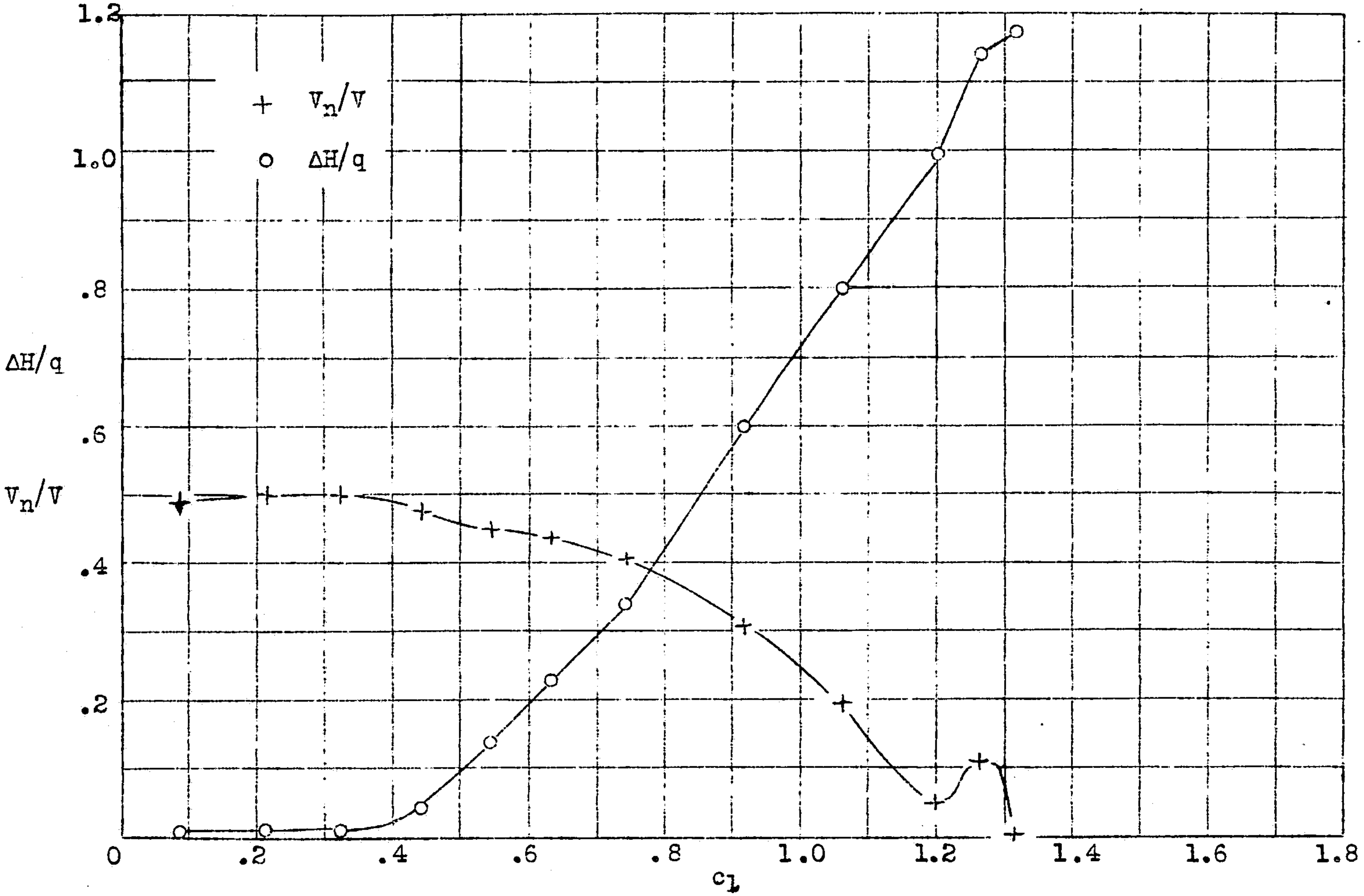

Figure 6.- Flow characteristics for gun port 1. α, 0^{o}; R, 3.77×10^{6}; A_t/A_n, 0.559.

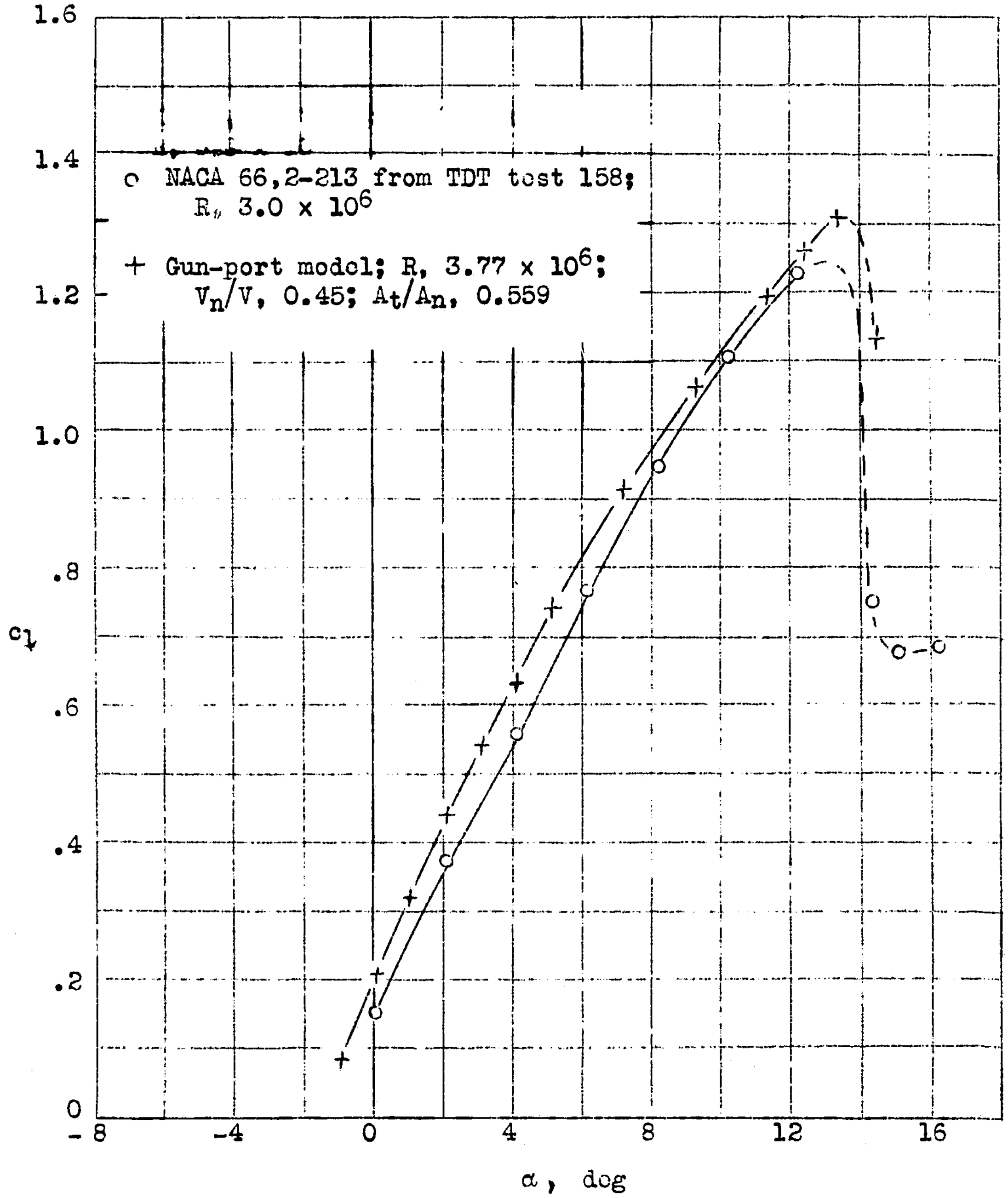

Fig 7.- Comparison of section lift coefficients of NACA 66,2-213 airfoil section and the model with gun port.

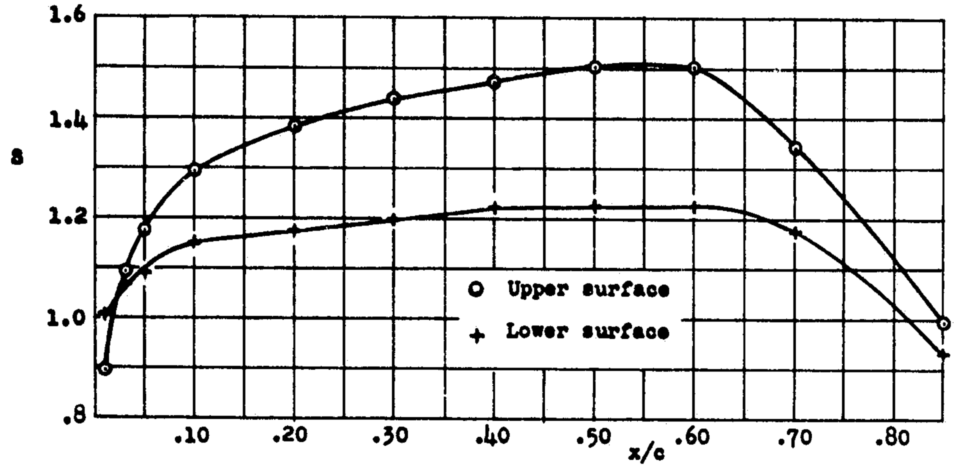

Figure 8.- Pressure distribution for the NACA 66,2-213 airfoil section measured 9 inches to the right of the center line of the opening. α, 0°; R, 3.77×10^6; V_n/V, 0.45; A_t/A_n, 0.559.

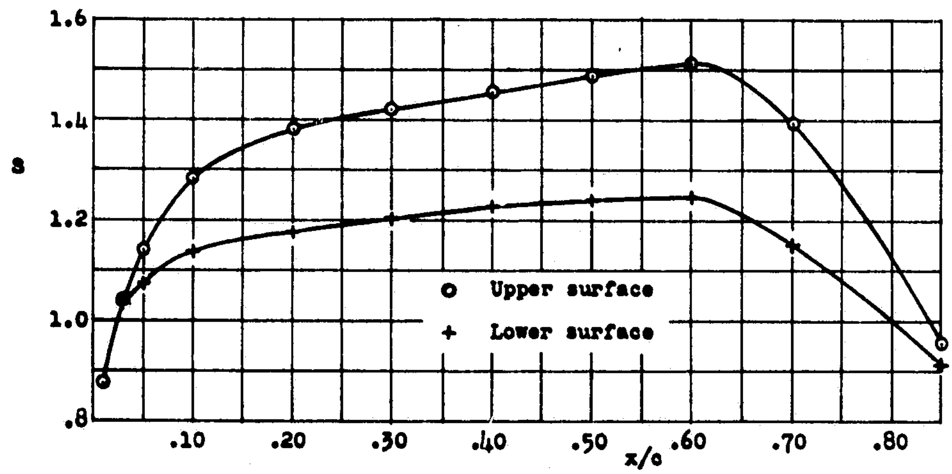

Figure 9.- Pressure distribution for the gun-port model at the center line of the opening. α, 0°; R, 3.77×10^6; V_n/V, 0.45; A_t/A_n, 0.559.

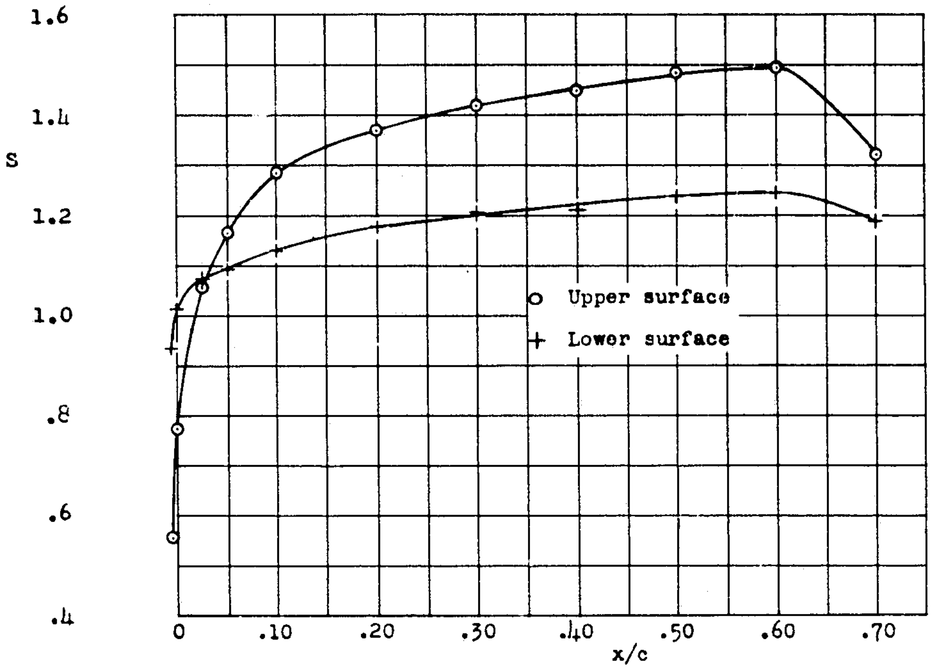

Figure 10.- Pressure distribution for the gun-port model on a line $1\frac{1}{2}$ inches to the right of the center line of the opening. α, 0°; R, 3.77×10^6; V_n/V, 0.45; A_t/A_n, 0.520; x/c = 0 corresponds to leading edge of the original section.

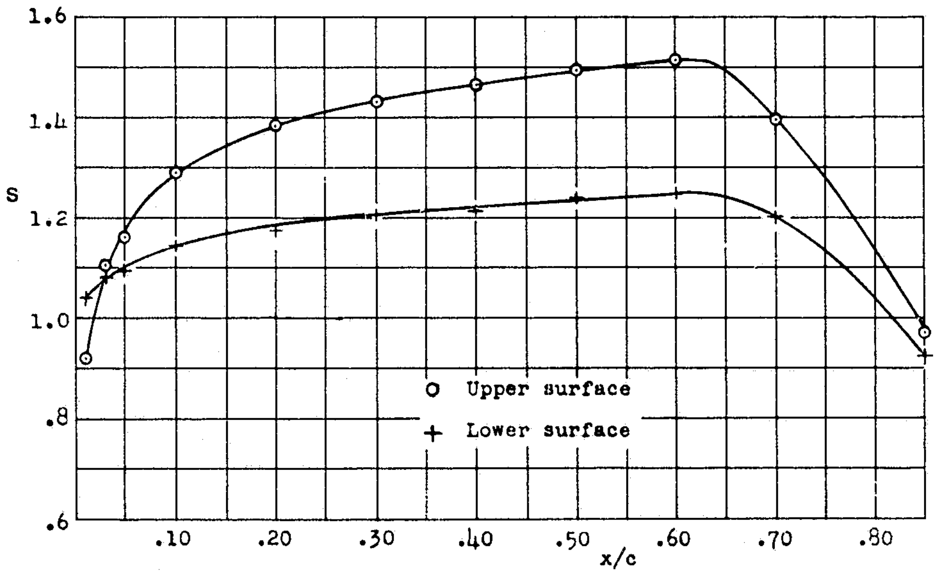

Figure 11.- Pressure distribution for the gun-port model on a line 3 inches to the right of the center line of the opening. α, 0°; R, 3.77×10^6; V_n/V, 0.45; A_t/A_n, 0.559.